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EVALUATION OF TWO CARBOFURAN SOIL INCORPORATING SYSTEMS

By

Larry R. Barber
Entomologist

SOUTHEASTERN AREA, STATE & PRIVATE FORESTRY
USDA FOREST SERVICE, ATLANTA, GA 30309

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ABSTRACT

Tests during February 1976 determined that neither the standard farm disk nor the Zip Seeder (ZF-6 double hopper) would satisfactorily incorporate carbofuran granules into seed orchard soils. This report documents the first attempt at operational field application of carbofuran using mechanized equipment for application and incorporation. In general, seed and cone insects were controlled with one spring application.

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INTRODUCTION

The Southern Seed Orchard Pest Committee 2/ coordinated work during 1974 and 1975 to obtain registration of carbofuran 3/ 10 percent granules for controlling coneworms and seedbugs in southern pine seed orchards. Tests were conducted in 10 orchards in 1974 and in 15 in 1975 (DeBarr 1978). The carbofuran in these tests was applied by hand held shakers and raked or disked into the soil and duff. A faster and more efficient method would be needed for applying carbofuran on an operational basis.

1/ Entomologist, Forest Insect and Disease Management, Southeastern Area S&PF, Asheville, N.C.

2/ Members include representatives of three southern seed orchard cooperatives (North Carolina, Florida, and Western Gulf); one from states not represented by cooperatives; T.V.A., universities, Southeastern Area, State and Private Forestry, U.S. Forest Service; the National Forest System, U.S. Forest Service; and from Research, U.S. Forest Service.

3/ This publication reports work involving pesticides and equipment It does not contain recommendations for their use, nor does it imply that the uses discussed have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended. Furadan® is the trade name for carbofuran.

This evaluation was developed by the Subcommittee on Carbofuran Applicator System Testing for the Southern Seed Orchard Pest Committee. A preliminary draft of the study plan was presented to the Southern Seed Orchard Pest Committee in Atlanta, Georgia on November 25, 1975. The evaluation began in February 1976 at the Erambert Orchard near Brooklyn, Mississippi.

The objectives of this evaluation were:

1. To determine if under seed orchard conditions either a standard farm disk or a Zip Seeder (ZF-6) would satisfactorily incorporate carbofuran (10 percent granules) into the soil.

2. To determine if carbofuran incorporated into the soil by either a standard farm disk or the Zip Seeder (ZF-6) would control seed and cone insects, i.e., coneworms, seedworms and seedbugs.

METHODS AND MATERIALS

Test Seed Orchards

Three seed orchards were selected for the study by Dr. Bob Weir [4/] and Dr. Gary DeBarr [5/]. Selections were made on the basis of past histories of insect problems, soil types and geographic locations.

Plots were installed on loblolly pines, Pinus taeda L. at the Erambert Seed Orchard (USFS) near Brooklyn, Mississippi, Arrowhead Seed Orchard (Georgia Forestry Commission) near Cochran, Georgia, and the Chesapeake Seed Orchard (Chesapeake Corporation of Virginia) near West Point, Virginia.

For each orchard six clones, (two ramets of each) were chosen as study trees in each treatment block. Within an orchard the same six clones were used throughout the study treatments.

4/ Assistant Professor, North Carolina State University, Industry Cooperative Tree Improvement Program, Raleigh, N.C.

5/ Principle Research Entomologist, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, GA.

The machinery used to apply carbofuran were the farm disk and the Zip Seeder (ZF-6, double hopper) made by Midland Manufacturing Company, Inc., Electric Mills, Mississippi. The Zip Seeder has 12 coulters, drop tubes and packing wheels spaced 9 inches (23 cm) apart.

The carbofuran was to be applied and incorporated into the top 3 inches (7.5 cm) of the soil. It was felt that deeper incorporation would cut too many feeder roots resulting in reduced uptake of carbofuran thereby reducing insect control.

The Zip Seeder was calibrated by: 1) placing a predetermined amount of calibration granules in the Zip Seeder hopper, 2) operating the seeder over a known distance, 3) weighing the granules remaining in the hopper, and 4) adjusting the flow regulator bar (hole size over drop tube) to either increase or decrease the flow rate to correspond to the predetermined calculated flow rate.

In this study the planned application rate was 8 oz. (226.8 g) of carbofuran per inch (2.54 cm) of tree dbh. Because of calibration problems, application rates ranged from 4.9 to 8 ounces (139 to 227 gm) per inch of dbh.

Coneworm damage was determined by calculating the percent of coneworm infested cones on each ramet. Seed analysis consisted of collecting six apparently healthy cones from each ramet. The seeds were extracted from these cones and radiographed to determine the percent of full, empty, seedbug damage, and seedworm infested seeds.

When this study was installed methods were not available to quantify carbofuran granule incorporation.

In each seed orchard a randomized complete block design was used with clones as blocks. An analysis of variance and Duncan's Multiple Range Test were run on the resulting data.

Erambert Seed Orchard

On February 4-5, 1976, carbofuran was applied to two blocks containing 4 rows of 25 trees each. Both blocks received carbofuran at 8 oz. (226.8 g) per inch (2.5 cm) of dbh. Orchard spacing was 15 ft. (4.6 m) between trees with 30 ft. (9.1 m) between rows.

The first block received carbofuran broadcast by hand drawn lawn fertilizer spreader (Figure 1) and was then disked three times (broadcast disk method) to a depth of 4-8 inches (10-20 cm).

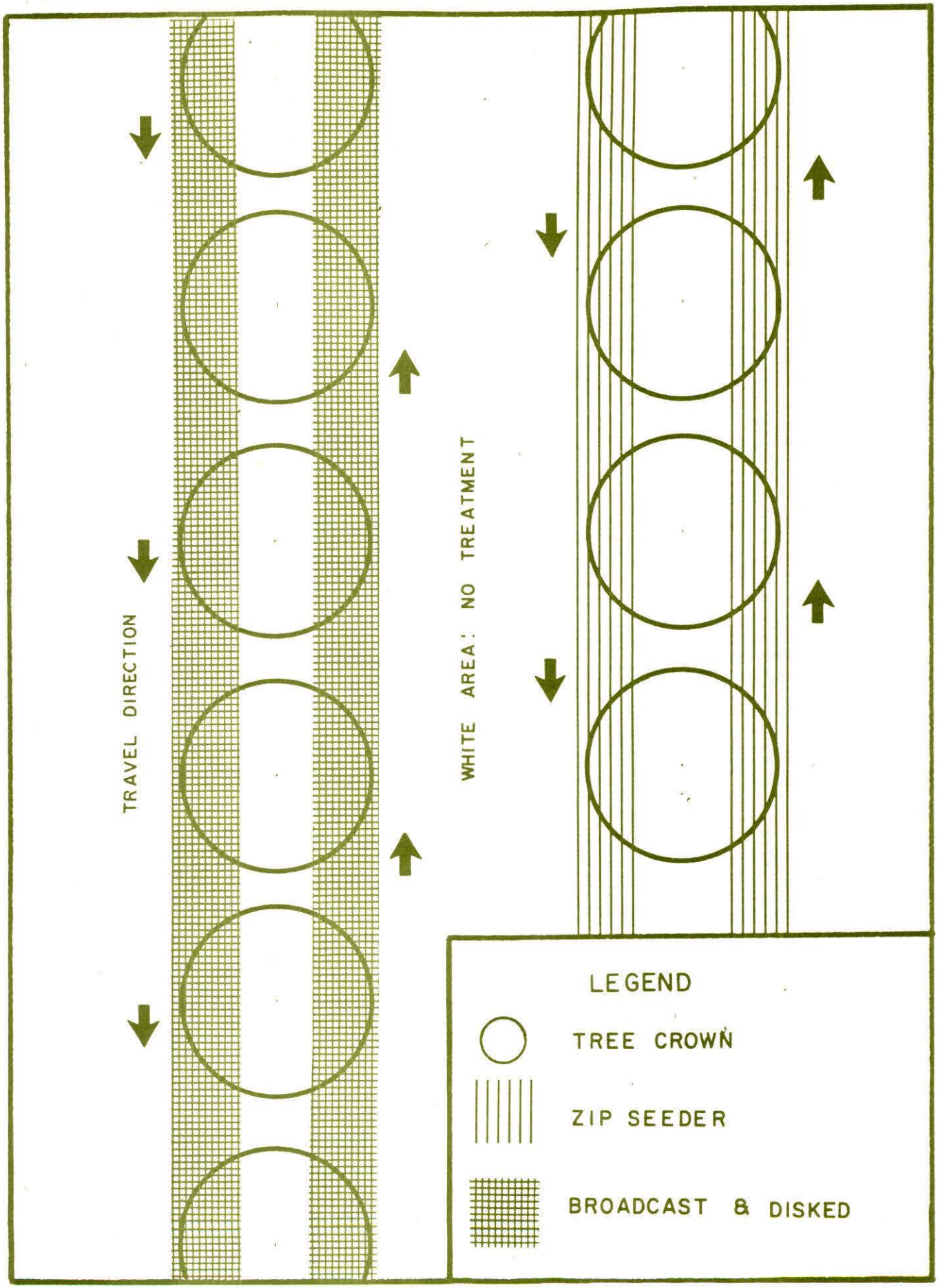

Figure 1. Application systems for Zip Seeder and disked area, also showing area of no treatment.

A second block received carbofuran applied with the Zip Seeder (Figure 1) while the third block received no insecticide treatment. Both treatment and check areas were raked clear of ground litter four months before the study.

Arrowhead Seed Orchard

An entire block of 400 loblolly pines spaced 16 feet (4.9 m) between both trees and rows was set aside for this evaluation. The block was raked prior to treatment to remove 2 to 4 inches (5-10 cm) of accumulated pine straw. Six rows of twenty trees each were treated on February 12, 1976 with the broadcast disk treatment, while an equal number of trees were left untreated in the check area. The remaining trees in the block were set aside for a buffer strip between treatments. The Zip Seeder was used to spread the carbofuran at 5.8 oz. (164.4 g) per inch (2.5 cm) dbh (Table 1). Immediately thereafter, the soil was disked to a depth of 2-3 inches (5-7.5 cm). Hard clay soil limited further depth penetration. The Zip Seeder treatment alone was not used because the seeder would not penetrate the soil or cover the carbofuran adequately.

Chesapeake Seed Orchard

The heavily rogued block of trees selected for the evaluation contained 135 loblolly pines originally spaced 15 ft. (4.6 m) between rows and trees. Both the broadcast disk and Zip Seeder methods were used to apply carbofuran at 4.9 oz. (139 gm) per inch (2.5 cm) dbh. For the broadcast and disk treatment, the Zip Seeder was used to dispense the carbofuran granules. The treated area was then disked three times to a depth of 4 in. (10.2 cm). In another area the Zip Seeder alone was used. An additional area was left untreated. The broadcast disk, Zip Seeder and no treatment areas were raked prior to carbofuran application to remove 1-2 in. (2.5-5.1 cm) of accumulated pine straw. The entire block was subdivided into six subplots (two check, two Zip Seeder, and two broadcast disk) containing approximately 23 trees each.

Residue Analysis

Analysis of carbofuran residues were conducted on cone, conelet, and needle samples from the Erambert Orchard. Samples were collected in both the Zip and disk areas on October 10, 1976 and forwarded to Dr. Gary DeBarr for residue analysis.

RESULTS

Incorporation

Field observations showed the broadcast disk method to be an unacceptable procedure for incorporating carbofuran. Carbofuran granules were easily observed on the soil surface following disking. The disking treatment

Table 1. Carbofuran evaluation treatment sites: tree diameters and application rates for 1976.

Date Applied	Seed Orchard/Location	Average DBH Inches	Carbofuran Per Tree Oz. Zip Seeder	Carbofuran Per Tree Oz. Disk	Rate Per Inch DBH Oz.
2/4-5/76	Ashe Erambert Brooklyn, MS	6.9 (17.5 cm)	55.4 (1.6 kg)	55.4 (1.6 kg)	8.0 (226.8 gm)
2/12/76	Arrowhead Cochran, GA	9.2 (23.4 cm)	None	52.8 (1.5 kg)	5.8 (164.4 gm)
2/18/76	Chesapeake West Point, VA	12.2 (31.0 cm)	59.3 (1.6 kg)	59.3 (1.6 kg)	4.9 (138.9 gm)

also destroys the sod cover, cuts feeder roots and at least temporarily makes vehicular travel difficult. Operation of the vacuum seed harvester for seed collection may also be affected.

The Zip Seeder (ZF-6) as used in our test also proved to be inadequate for carbofuran incorporation. The problem areas encountered with the Zip Seeder are as follows:

1. The ZF-6 was unable to penetrate hard dry clay soils (Georgia), and in soft sandy loam it dug in and plowed or pushed the soil (Virginia).

2. The ZF-6 becomes clogged with pine needles and ground litter unless the area is well raked beforehand (Georgia, Virginia).

3. The Zip Seeder was very difficult to calibrate. The varying rates of material applied in each orchard are a reflection of this. However, once application began, the machine dispensed the material in a uniform manner throughout the particular test area.

4. The ZF-6 did not adequately cover or "incorporate" the carbofuran. In many cases the machine made a trench too small for the amount of material applied, and it could not cover the carbofuran. A significant danger to wildlife exists if this machine is used to apply carbofuran 10% granules.

5. The Zip Seeder is constructed so that all drop tubes are an equal distance from the ground and are at fixed positions over the 4 1/2 ft. (1.4 m) span of each hopper. As a result, on uneven terrain one hopper may lift out of the ground and spill the insecticide.

On May 12, 1976, Dr. Bob Wier, Dr. Gary DeBarr, Larry Barber and others met in Raleigh, NC to test the incorporation effectiveness of the new John Deere Model 1500 Powr-Till Seeder and the broadcast disk treatment. Using a technique worked out by DeBarr and Barber, blank non-toxic granules were labeled with Leucophor® fluorescent dye and viewed after application with the aid of a "black light". This method allowed a quantitative evaluation of granular incorporation.

In the broadcast disk treatment a known number of granules were distributed evenly over a 100 sq. ft. area (30.5 sq m) which was then disked. The granules remaining on the soil surface were fluorescented with a black light, counted, and the number compared with the number known to be present and a percent incorporation figure developed.

Only 90-95 percent of the granules were incorporated with the broadcast and disk treatment. A similar evaluation was not made with the Zip Seeder. Field observations, however, indicate incorporation was considerably less than 90 percent.

Using a similar procedure, an evaluation of an unmodified John Deere Powr-Till Seeder showed granular incorporation to be in excess of 95 percent. Drop tube modifications increased incorporation to 99.9 percent under ideal conditions.

Insect Control

Percent coneworm damage was significantly different between the untreated and the Zip Seeder treated trees on both the Erambert and Chesapeake Orchards (Table 2). No statistical difference was found between the disk and untreated treatments on these two orchards. There was also no significant difference between the broadcast disk and check treatment on the Arrowhead Orchard for coneworm damage.

Seedbugs were controlled on the Arrowhead and Erambert Orchards as shown by the reduction of seedbug damaged seed and by the increases in full seed in the treated trees. Significantly more empty seed was found in the untreated areas on the Erambert and Arrowhead Orchards. Most empty seed is attributable to seedbugs. Broadcast disk and Zip Seeder treatments increased full seed 2.8 and 2.7 times respectively over untreated trees at the Erambert Orchard. There were significantly more full seed per cone in the disk treatment trees than in the check trees on the Arrowhead Orchard (17 percent increase) and on the Erambert Orchard (30 percent increase).

Overall, identifiable seedbug losses were low on all orchards - the only significant differences were on the Erambert where less identifiable seedbug damaged seed was found in the disk area as compared to the check.

Seedworm control was good on all orchards. Both disk and Zip Seeder treatments were significantly better than untreated check treatment trees on the Chesapeake and Erambert Orchards. On the Arrowhead the disk treatment was significantly better than no treatment.

Wildlife Losses

It is well known that many insecticides are hazardous to wildlife, however, wildlife losses were not anticipated with carbofuran because none had been reported in tests to gain registration. In this evaluation dead robins were found following carbofuran application in the Erambert and Arrowhead Seed Orchards. The following data documents these losses.

Table 2. Analysis of cones and seeds harvested from three orchards in which carbofuran was applied in the spring of 1976 by either a Zip Seeder or broadcast followed by disking.

	Ashe Erambert Seed Orchard - U.S.F.S.[1/]			Arrowhead Seed Orchard Georgia Forestry Comm.[2/]		Chesapeake Corporation of Virginia Seed Orchard[3/]		
	Disk[4/]	Zip[5/]	Check[6/]	Disk	Check	Disk	Zip	Check
	PERCENT							
Coneworm Infested Cones	3.5ab	2.7b	9.0a	6.5	9.4	9.5ab	6.8b	13.4a
Full Seed	57.8a	56.5a	20.8b	79.3*	62.0	76.1a	77.7a	76.9a
Empty Seed	42.2a	43.3a	73.5b	20.5*	33.1	23.7a	21.9a	18.6a
Seedbug Damaged Seed	.1a	.3ab	.7b	.1*	2.0	.1a	.3a	.6a
Seedworm Infested Seed	.0a	.0a	5.0b	.1*	2.3	.1a	.2a	3.9b

Percent means followed by same letter are not significantly different at 5 percent probability level, Duncan's multiple range test. Comparisons are made within each orchard only.

* = significant difference exists between treatment.

1/ Dosage rate - 8.0 oz. per inch DBH.
2/ Dosage rate - 5.8 oz. per inch DBH.
3/ Dosage rate - 4.9 oz. per inch DBH.
4/ Disk - broadcast.
5/ Zip - Zip Seeder applied.
6/ Check - no treatment.

A total of 16 dead robins (Turdis migratorius) were found in the Zip Seeder and broadcast disk areas at the Erambert Orchard within 48 hours of application. It was assumed the mortality resulted from carbofuran ingestion.

U. S. Department of Commerce weather information indicated 0.42 inches (1.05 cm) of rain fell in nearby Wiggins, Mississippi and 1.31 inches (3.33 cm) fell in Hattiesburg 40 miles from the orchard a day after (February 6) the treatment applications. No bird mortality was recorded after the rainfall.

At the Arrowhead Seed Orchard, 26 robins were killed within 24 hours of carbofuran application. An analysis of the stomach contents of two birds showed that one bird ingested one granule and the other ingested two granules.

No bird mortality was reported on the Chesapeake Orchard. The reason for the reduced bird mortality may have been the migratory flocks of birds were not present on this orchard as they were on the other two orchards. The Zip Seeder also covered the carbofuran more effectively in the softer textured soils in Virginia thereby making the granules less available to birds.

Residue Analysis

Total toxic residues expressed in parts per million (ppm) were found to be much higher in the needles than in either cones or conelets (Table 3). Carbofuran and its metabolites detected, include carbofuran, 3-Keto carbofuran and 3-OH carbofuran which, when combined, make up the total toxic residues.

Needle samples from the disk treatment area had total toxic residues of 23.17 ppm as compared to 19.88 ppm in the Zip Seeder treatment. This relationship of higher residues with disk treatment was also observed in cone and conelet samples.

DISCUSSION

This test documents the first operational control of seed and cone insects with carbofuran granlues. The Zip Seeder treatment significantly reduced coneworm damage on the Chesapeake and Erambert Orchards. Coneworm control with the disk treatment either was erratic or was not significantly different from the check trees (Arrowhead).

The percentage of filled sound seed per cone increased on each orchard where carbofuran was applied. On the Erambert a 2.8 fold increase in full seed was documented in the disk versus the check treatment areas. Seedworm control was achieved with carbofuran on the Erambert, Arrowhead and Chesapeake Orchards.

Table 3. Carbofuran and toxic metabolities in loblolly pine samples collected at harvest - Erambert Orchard, Brooklyn, Mississippi.[1/]

Sample	Treatment Method [2/]	Average Concentration (ppm)[3/]			
		Carbofuran	3-Keto Carbofuran	3-OH Carbofuran	Total Toxic Residues
Needles	Zip	6.26	0	13.62	19.88
	Disk	7.73	0	15.44	23.17
Cones	Zip	0.26	0	0	0.26
	Disk	0.32	0	0	0.32
Conelets	Zip	0	0	0	0
	Disk	1.42	0	0	1.42

1/ Needle, conelet and cone samples collected October 10, 1976.

2/ Carbofuran 10 percent granules applied at 8 oz. per inch DBH with either the Zip Seeder or broadcast followed by disking February 4-5, 1976.

3/ Sensivitity of 0.2 ppm carbofuran, 0.5 ppm 3-keto carbofuran, and 1.0 ppm 3-OH carbofuran.

Results of this study showed neither method was acceptable for applying and incorporating carbofuran granules and cannot be recommended for the following reasons:

Disk

1. Unsatisfactory granule incorporation.
2. Sod cover destruction, possibly resulting in soil erosion.
3. Penetration too deep - cuts feeder roots.
4. Ineffective in hard compacted soils.

Zip Seeder

1. Unsatisfactory granule incorporation.
2. Failure to operate in heavy grass or pine straw.
3. Ineffective in hard compacted soils.
4. Precise rate calibration difficult.

Wildlife losses of any magnitude are regrettable and in this evaluation were unexpected. All efforts should be made in the future to minimize these losses. In 1977, State and Private Forestry, Forest Insect and Disease Management, initiated a pilot study to evaluate the John Deere Model 1500 Powr-Till Seeder as a tool to incorporate carbofuran granules. Test data indicates that with modifications this machine will incorporate granules better than either the Zip Seeder or the disk. This greater degree of incorporation should decrease the availability of the granules to bird populations. The results of this evaluation will be available in 1979.

In addition to better incorporation, timing of carbofuran applications may also play an important role in reducing bird mortality. Application could be timed to coincide with low bird populations present on orchards. Applying granules immediately before significant rainfall might also reduce mortality.

State and Private Forestry in 1977 cooperated in an evaluation with the Catawba Timber Company near Rock Hill, South Carolina to determine if carbofuran could be applied with a broadcast applicator and incorporated with sprinkler irrigation water. The results of this study show bird populations were low during and after granule application, correspondingly, bird mortality was also low. Coneworms were controlled with one application of carbofuran. There were no significant differences between treated and untreated trees for seedbug damaged seed, empty or full seed. A report on the 1977 evaluation "Bird Mortality and Insect Control When Using Carbofuran on Catawba Timber Company's Irrigated Pine Seed Orchard, Catawba, South Carolina" (Hertel and Barber, 1978), was published in 1978.

Commercially available bird scaring devices have been suggested as another means of reducing mortality on carbofuran-treated orchards. Bird-repelling chemicals such as Arasan® may be another alternative method of moving bird populations away from a treated orchard. Both methods are untested.

Luring the birds away from the carbofuran-treated areas to baited fields or disked feeding zones might also be effective at moving birds from an orchard.

RECOMMENDATIONS

Neither the Zip Seeder nor the disk can be recommended as tools to incorporate carbofuran granules. Recommendations concerning the John Deere Model 1500 Powr-Till Seeder will be made in 1979 at the completion of the Powr-Till Seeder Pilot Study.

Research should be initiated to find new methods of managing orchard bird populations as well as methods to predict their presence or absence on orchards. Researchers should investigate methods and materials that would either disguise carbofuran granules or make them repugnant to birds.

The effect of rainfall on reducing bird mortality should also be investigated. Research needs to determine the method of carbofuran ingestion by wildlife, i.e., water from puddles, granules, earthworms, or insects, etc.

Work should continue on evaluating and modifying the John Deere Powr-Till Seeder to improve its performance in incorporating carbofuran granules.

Additional work is needed to determine the fate of carbofuran in the environment. Both rate and timing evaluations should be conducted on each orchard in order to maximize the effectiveness of future carbofuran applications.

ACKNOWLEDGEMENTS

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